AN417; WATTNODE WNB PULSE WEIGHT CALCULATION:

Watt-hours per pulse for a standard 4Hz FS output meter are shown in the right four columns of Table 6 from the Wattnode WNB user manual (copied below).

For quick calculation:

Find the Wh per pulse in table for the appropriate model

Multiply the table value by the ratio of the [Standard Full Scale Freq /Custom Full Scale Freq]

For example:
If it is a standard 4Hz output unit then multiply by 4Hz/4Hz (ie 1)

If it is a 400Hz custom output then multiply the value in the table by 4/400

For example, a 3Y-208 meter with 100Aac CT's outputs 2.5Wh per pulse (direct from the table)

If a 40Hz FS meter was ordered (custom) then each pulse would be 2.5 x (4/40) = 0.25Wh

For a 300 Hz meter, each pulse = 2.5 x (4/300) = 0.0333 Wh

CT Size (amps)	Pulses Per kilowatt-hour (*PpKWH*)				Watt-hours per pulse (*WHpP*)			
	3Y-208 3D-240	3Y-400 3D-400	3Y-480 3D-480	3Y-600	3Y-208 3D-240	3Y-400 3D-400	3Y-480 3D-480	3Y-600
5	8000.00	4173.91	3465.70	2766.57	0.125	0.2396	0.2885	0.3615
15	2666.67	1391.30	1155.24	922.190	0.375	0.7188	0.8656	1.0844
20	2000.00	1043.48	866.426	691.643	0.500	0.9583	1.1542	1.4458
30	1333.33	695.652	577.617	461.095	0.750	1.4375	1.7313	2.1688
50	800.000	417.391	346.570	276.657	1.250	2.3958	2.8854	3.6146
60	666.667	347.826	288.809	230.548	1.500	2.8750	3.4625	4.3375
70	571.429	298.137	247.550	197.612	1.750	3.3542	4.0396	5.0604
100	400.000	208.696	173.285	138.329	2.500	4.7917	5.7708	7.2292
150	266.667	139.130	115.523	92.219	3.750	7.1875	8.6563	10.844
200	200.000	104.348	86.643	69.164	5.000	9.5833	11.542	14.458
250	160.000	83.478	69.314	55.331	6.250	11.979	14.427	18.073
300	133.333	69.565	57.762	46.110	7.500	14.375	17.313	21.688
400	100.000	52.174	43.321	34.582	10.000	19.167	23.083	28.917
600	66.667	34.783	28.881	23.055	15.000	28.750	34.625	43.375
800	50.000	26.087	21.661	17.291	20.000	38.333	46.167	57.833
1000	40.000	20.870	17.329	13.833	25.000	47.917	57.708	72.292
1200	33.333	17.391	14.440	11.527	30.000	57.500	69.250	86.750
1500	26.667	13.913	11.552	9.2219	37.500	71.875	86.563	108.44
2000	20.000	10.435	8.6643	6.9164	50.000	95.833	115.42	144.58
3000	13.333	6.9565	5.7762	4.6110	75.000	143.75	173.13	216.88
any	40,000 *CtAmps*	20,870 *CtAmps*	17,329 *CtAmps*	13,833 *CtAmps*	*CtAmps* 40	*CtAmps* 20.87	*CtAmps* 17.329	*CtAmps* 13.833

Table 6: Scale Factors - Bidirectional Outputs

AN-415: INTERFACING PULSE OUTPUT POWER METERS TO THE INTELLILOGGER

Many equipment or building Energy consumption and Power demand studies utilize power meters with pulse outputs interfaced to the IntelliLogger for reporting, alarming and archiving usage profiles. Through the use of standard counter input(s) available on all models of the IntelliLogger and the programming flexibility of HyperWare-II, the IntelliLogger can meet the needs of nearly all applications in this field.

A few of the data acquisition and reporting features that can be implemented:

- **Periodic Totalization** – including utility interval (e.g. 15 minute) totals, as well as other time or event based totals and running (i.e. non-clearing) totals

- **Demand (kW) Calculation** – calculate demand from pulse frequency

- **Periodic FTP of Data** – for archiving purposes on a remote FTP Server

- **Billing Calculations** – simple to tiered billing and totalizations

- **EMail Alerts** – send Email or Text message alerts upon events (e.g. demand threshold exceedance)

- **Serve Web Page data** – with embedded current values and/or totals and more

EXAMPLE POWER METER – WATTNODE WNB SERIES

The WattNode WNB series power meter (Figure 1) is a self-contained device that utilizes Current Transformer (CT) inputs for Aac measurement and direct Vac connection for voltage measurement on each phase of the utility supply to a load. The device then calculates Watt-hours (energy) and periodically outputs a pulse each time some defined quantity of energy (Wh) has passed to the load.

By counting (totalizing) these pulses over a period of time the Consumption can be logged and reported in various ways as described above.

Many other meters on the market operate in the same way however the WNB will be used for this Application Note. Details specific to the WattNode model selection, CT sizing and selection and voltage ranges are available on our Web site: www.logicbeach.com/sensors/sen-indx.html

WNB Installation and wiring instructions are provided with the unit.

WH (ENERGY CONSUMPTION) PULSE OUTPUT USE WITH THE INTELLILOGGER

The WNB has a pulse output that can be simply viewed as a switch that momentarily closes periodically indicating that a quantity of Wh has passed to the load. This switch pulse can be connected to any of the IntelliLogger Digital Inputs which are then configured as Counters via the HyperWare-II software (Figure 3 and 4) Digital Input Configuration Dialog.

As the switch simply shorts its contacts, the IntelliLogger must provide an excitation voltage in order to measure whether the switch is open or closed. This is done by checking the "Enable Pull-Up" check box within the channel Configuration Dialog. To effect the "Pull-Up", the IntelliLogger internal circuitry connects a resistor from its internal power supply (3.3Vdc) to the (+) terminal on the channel terminal strip (Figure 2). Every time the WNB switch closes momentarily, the (+) terminal is shorted to IntelliLogger circuit ground and the voltage across the
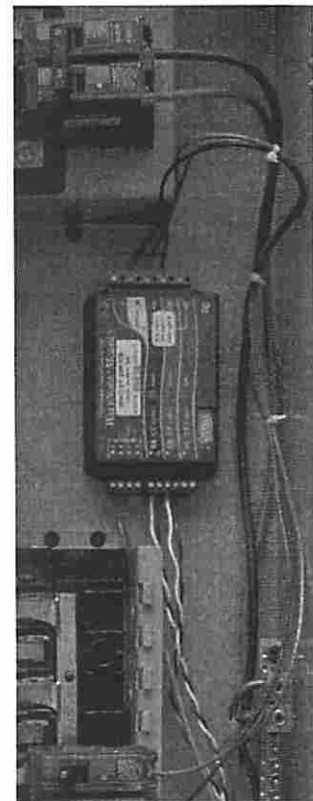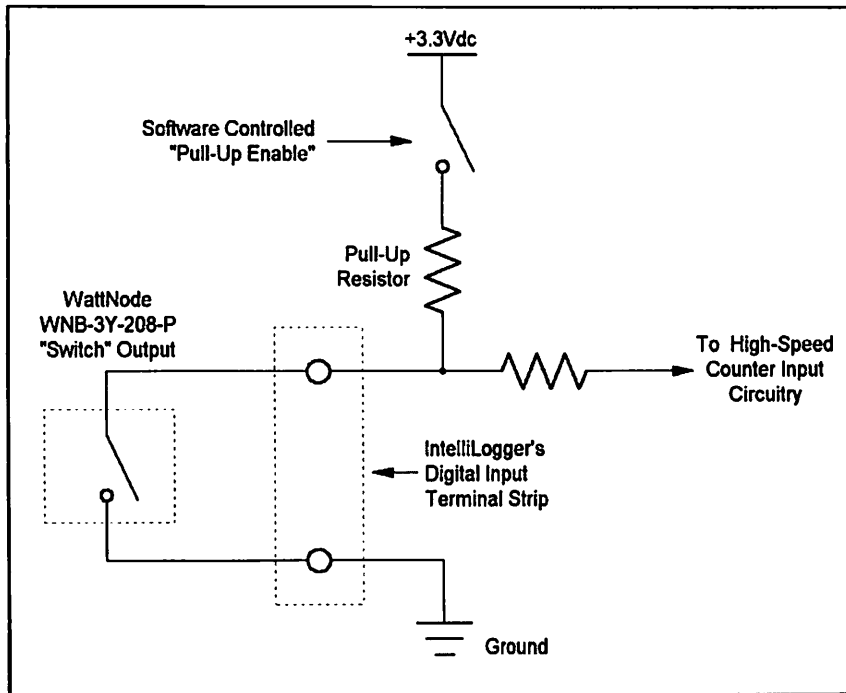

Figure 1; WattNode Install

Figure 2; IntelliLogger WNB Connection and Internal Circuitry

terminals collapses from 3.3Vdc (a High input) to 0Vdc (a Low input). This transition is then counted by the IntelliLogger and used per the user program.

Some meters (as well as other types of pulse output transducers such as flow meters) utilize mechanical switches instead of electronic switches as employed by the WNB. These switch contacts upon closure can actually mechanically bounce a few times... opening and shorting the input to the IntelliLogger Counter channel. Although these bounces occur very quickly and soon settle to a steady closed state, the IntelliLogger counter inputs are extremely fast and will count these "bounce" transitions, resulting in erroneous Wh totals. To preclude this in mechanical switch applications, the "Enable Debounce Filtering" check box can be checked within the Channel Configuration Dialog. This function filters out (ignores) the very fast contact bounce.

ENERGY PER PULSE CALCULATION

The energy that each pulse represents is a function of the WNB model (full scale frequency output spec) and the Full Scale current rating of the CT's employed. Details on a multitude of various calculation methods are provided in the WNB User Manual however a simple and effective calculation follows.

The WNB is shipped from the manufacturer with an Energy scaling constant printed on the back and termed *Watt-hours per pulse per CT rated amp* (WHpPpA) which represents Watt-hours per Pulse per Full Scale CT Amperage Rating. To determine the Energy (in Wh) per Pulse multiply this factor times the Full Scale Amperage Rating of the CT's used.

For example, a common part, the WNB-3Y-208-P model has a WHpPpA scaling constant of 0.025. With 50 Aac Full scale CT's, the Energy per pulse is calculated as follows:

$$\text{Watt-hours per Pulse} = 0.025 \times 50 = 1.25$$

If an IntelliLogger input channel were to totalize 1800 pulses in a day, that would then represent a day's energy consumption of:

$$\text{Watt-hours per Pulse x Qty of Pulses} = \text{Energy Total}$$

Or in this example...

$$1.25 \times 1800 = 2250 \text{ Watt-hours of Energy (i.e. 2.25kWh)}$$

Once the WHpPpA constant for the WNB and the CT Full Scale Current Ratings are known for an installation, this calculation can be simply programmed into a Math icon within the IntelliLogger program developed within HyperWare-II. The Energy can then be totalized over the desired period(s) with the addition of additional Summing icons in the Program.

PROGRAMMING THE INTELLILOGGER FOR ENERGY TOTALIZATION

Through the use of HyperWare-II, a Program Net can be quickly built to totalize and log the Energy consumption characteristics of a load using the above information. Familiarity with HyperWare-II programming is assumed for the following example. If unfamiliar with HyperWare-II, go to www.logicbeach.com to download training videos, manuals, software, etc., or contact Logic Beach staff for more information.

PROGRAM REQUIREMENTS

It is desired to employ the IntelliLogger to total energy consumption at 15 minute intervals from a WNB and stores the data to memory for later FTP to a Server. It is desired that the 15 minute intervals start/end on real-time "quarter hour" marks. Additionally, it is desired to store a Daily Total as well as keep a running (i.e. non-clearing) Energy Consumption Total that never resets.

PROGRAM NET

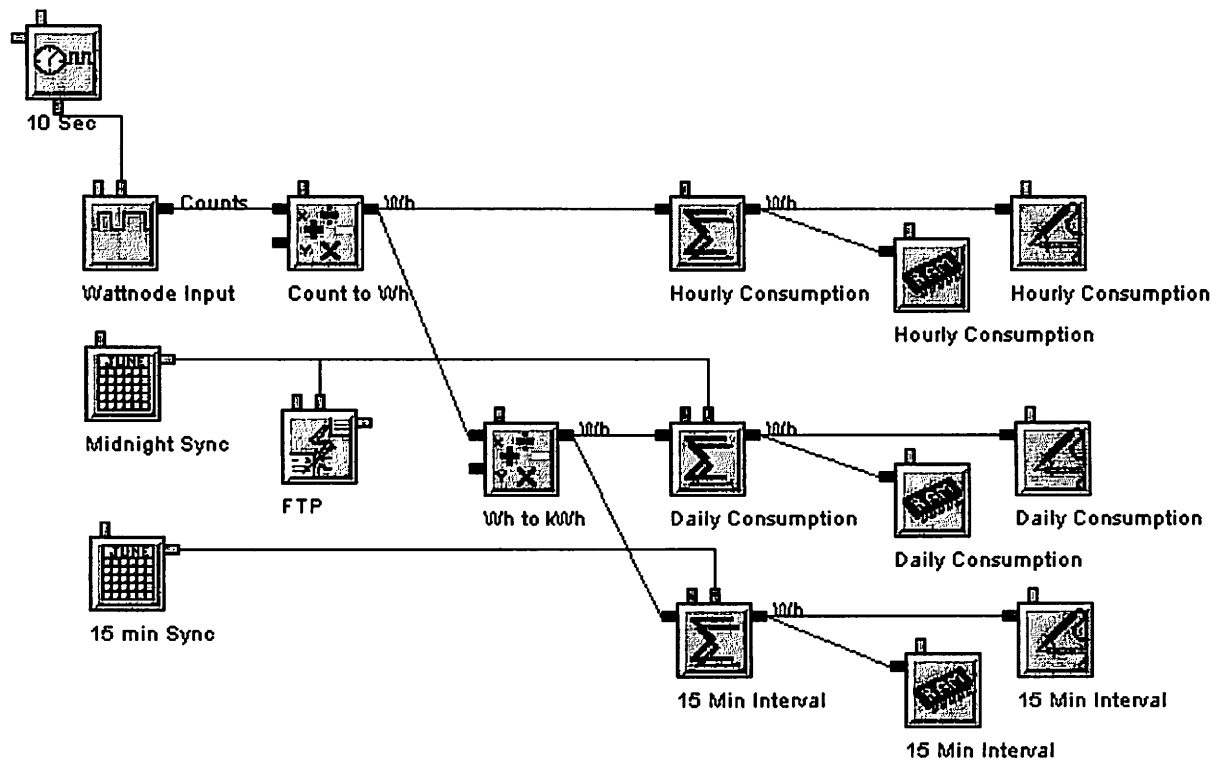Using HyperWare-II, a Program Net is developed (Figure 3) to implement the above requirements.

Figure 3; Consumption Program Net

In the program net in Figure 3, the WNB has been wired to a Digital Input channel configured as a Counter input labeled *Wattnode Input*. Every 10 seconds, the *10 Sec* Sample Rate Clock triggers the *Wattnode Input* icon to output its accumulated pulse count to the *Count to Wh* Math icon. Within the *Count to Wh* icon, the count is converted to Wh per the above described conversion equation. The

Hourly Consumption Summation icon totals the counts it receives and outputs its total every 360 samples, which at a 10 second sample rate becomes every 1 hour (10sec * 360 = 3600sec = 1hr). The Wh are also converted to kWh via the *Wh to kWh* Math icon, a more standard unit of consumption in the industry, and totaled both on a daily interval, and on a 15-minute interval. The *Midnight Sync* and *15 min Sync* Scheduler icons are used instead of Sample Rate Clocks to trigger the Summation icons to output their sums at specific times during the day, in this case at exactly midnight, and on each quarter hour (exactly 3:00, 3:15, 3:30, and 3:45 for example) to comply with typical utility billing intervals.

All of the stored data is then sent to a remote server via the FTP icon each midnight as triggered by the *Midnight Sync* icon.

DEMAND CALCULATIONS (WATTS)

In addition to Energy totalization, the WNB can also be used to measure Demand (i.e. the power level currently being delivered to the load) in Watts. This is performed by measuring the actual frequency output of the pulse train which is representative of Demand (Watts).

DEMAND CALCULATION

Since each pulse is equal to a Watt-hour quantity (i.e. power for a period of time) then measuring the frequency (pulses per unit time) will result in a division by time... resulting in power in Watts.

For example, if an Energy totalization is done for one hour and it results in 200 Watt-hours of energy consumed, then dividing by the counting interval time (in hours) would result in the average Power (in Watts) over that interval. In this example, the math would simply be:

$$200 \text{ Watt-hours} / 1 \text{ hour} = 200 \text{ Watts}$$

Another example... say the interval was 15 minutes and 300 pulses were counted. The math would then be:

$$300 \text{ Watt-hours} / 0.25 \text{ hours} = 1200 \text{ Watts}$$

IMPROVED DEMAND MEASUREMENT

The standard WNB is designed to output a 4 Hz pulse train at its Full Scale output. The WNB Full Scale output occurs when the measured Vac is at the rated voltage level and the CT's (regardless of their full scale Aac rating) are outputting 333mV. If it is desired to improve the power calculation accuracy or perform power (demand) readings more near to "instantaneous" (i.e. averaged over a much shorter interval) then the WNB can be ordered with a higher Full Scale frequency output... up to 600 Hz. With a 600Hz Full Scale output, device counts could be accumulated over a single second and the Power could then be calculated with 1 part in 600 resolution (i.e. +/- 1/600th of the WNB Full Scale rating). The result would be the average power over a one-second interval.

> Note: WNB models provided with non-standard Full Scale frequency outputs will have corresponding adjustments in their WHpPpA constant so calculations can simply proceed as above using the WHpPpA constant printed on the WNB.

PROGRAMMING THE INTELLILOGGER FOR DEMAND MEASUREMENT

Via HyperWare-II, the Program Net used above (Figure 3) for Energy (Consumption) has been modified (Figure 4) such that the current 10 second Demand level (in Watts) can be viewed real-time via a Web page served to a connected browser (*e.g.* over a LAN or the Internet), via the IntelliLogger front panel LCD and/or via HyperWare-II.
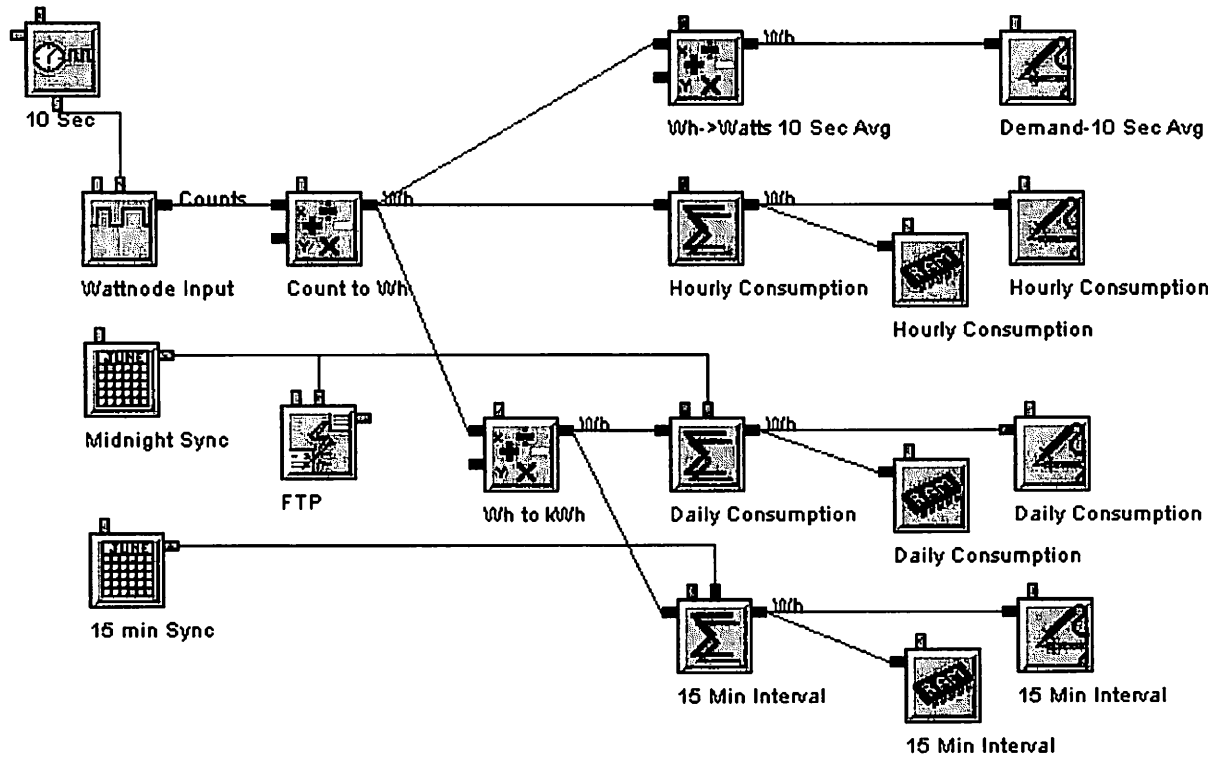
Figure 4; Consumption and Demand Program Net

PROGRAM ENHANCEMENTS FOR DEMAND MEASUREMENT

The *Wh->Watts 10 Sec Avg* Math icon and the *Demand-10 Sec Avg* Probe Point icon in Figure 4 are the only additions made to the program net in Figure 3 that are necessary to compute demand. The Math icon converts Wh to Watts by multiplying by 360, which is based on the following calculations:

$$\frac{x}{(\# \text{ of hours})} = \frac{x}{\left(10\sec \bullet \dfrac{1hr}{3600\sec}\right)} = \frac{x}{\left(\dfrac{1hr}{360}\right)} = x \bullet 360$$

Probe Point icons allow access to the 10 second Demand calculation via the IntelliLogger's LCD, browser access of the IntelliLogger as well as for inclusion into emails and text messages. To learn more about these, refer to the current IntelliLogger manual found here: www.logicbeach.com/manuals

> Note: If a higher Full Scale frequency output WNB is ordered, it is possible to directly measure the output frequency from the WNB using an IntelliLogger digital input configured as a Frequency Channel, however, this is not recommended as lower level frequencies (representing low load conditions) will not be capable of being read due to the minimum frequency input cutoff of the IntelliLogger Frequency input channels.

AN416; WATTNODE WNB PULSE OUTPUT THEORY

The WNB pulse output characterization can be confusing... at least to me. Here are some notes that may serve to clarify the relationship of Energy Wh and Power W as they relate to the Wattnode WNB electrical meter. Additionally, equations for Energy and Power are described as they would relate to programming a Logic Beach data logging instrument. Reference the user manual on the WNB product as well.

FULL SCALE POWER AND PULSE OUTPUT EXPLAINED...

The WNB has a specified full scale pulse output frequency of 4Hz standard (and can be provided with customs up to 600Hz). This means that when the maximum power level is being measured the WNB output pulse train frequency will be 4Hz.

The Full Scale Power level for the WNB depends on the model and the CT size connected. The equation for this Full Scale Power level is in the manual and is:

Full Scale Power (in Watts) = NVAC x PpPO x CT rating

The NVAC is the nominal Vac for the model and is given for each of the models in Table 8 in the manual and has been copied below.

WattNode Models	NVAC	Standard FSHz Values
WNB-3Y-208-P	120	4.00 Hz
WNB-3Y-400-P	230	4.00 Hz
WNB-3Y-480-P	277	4.00 Hz
WNB-3Y-600-P	347	4.00 Hz
WNB-3D-240-P	120*	4.00 Hz
WNB-3D-400-P	230*	4.00 Hz
WNB-3D-480-P	277*	4.00 Hz

Note: these Delta models utilize "virtual" phase-to-neutral voltages used for delta model power and energy computations and can not be directly measured.

The PpPO (Phases per Pulse Output) is "3" per the manual except for models that have a pulse output per phase or other specials. Even if the meter is installed on a single phase load, use 3 for this factor.

So for the WNB-3Y-400-P installed on a simple single phase 220Vac heater load the WNB Full Scale Power rating using a 1Aac CT (to normalize a bit) would be:

> 230 x 3 x 1 = 690W. At 690W power level, the pulse output would stream along at 4Hz. As another example, if a 20Aac CT was used, then the effective Full Scale Power rating would be:
> 230 x 3 x20 = 13800W.

PULSE OUTPUT CORRELATION TO ENERGY...

> From this it might be easier to understand what is going on ... for example using the same WNB model and the 20Aac CT's as above, the Watt Hours per Pulse (WHpP) can be calculated as follows:

13800W for an hour is 13,800 Wh.

In an hour at full power there would be 4Hz x 3600 seconds/Hr = 14,400 pulses.

To get the WHpP ...   13,800Wh/14400 = 0.958Wh per pulse (which conveniently agrees with the value in "Table 6; Scale Factors" in the WNB manual.

INCREASING MEASUREMENT RESOLUTION WITH CUSTOM F.S. PULSE OUTPUTS...

As mentioned above, theWNB meters can be ordered from the factory with higher frequency full scale (FS) outputs. Use of a meter with a FS output of 600Hz instead of the standard 4Hz allows for much higher energy measurement resolution as follows:

As another example... using the same 20Aac CT implementation as above but a WNB with a custom 600Hz output frequency

Same 13,800W level for an hour = 13,800Wh of energy

But divide that energy total by 600Hz x 3600 Sec/Hr (2,160,000 pulses) ...

13,800 / 2,160,000 = 0.00639Wh/pulse which is some fine resolution indeed.

MEASURING POWER BY MEASURING OUTPUT FREQUENCY...

In the last example above... this all distills down to the fact that at 0Hz output, the power level is 0W and at the Full Scale Output (13,800W) the output is 600Hz. So if an instrument can resolve 0.1Hz in measuring the frequency pulse train, then you can resolve the power level to 1 part in 6000 (600 taken in 0.1 steps) which corresponds to 13,800 / 6000 = 2.3W.

Relative to the IntelliLogger programming, a linear (mX + b) conversion can be used within a Math icon to output Instantaneous Power from a measured frequency. For example, with the WNB above that has a full scale output of 13,800W at 600Hz and 0W at 0Hz the conversion equation is simply the following ratiometric equation:

Instantaneous Power = (Measured Freq (Hz)/ FullScale Freq (Hz)) x 13,800

So for an example if the measured freq is 30Hz the Instantaneous Power would be

(30/600) x 13,800 = 0.05 x 13,800 = 690W

Document Revision History

4-19-12dp: First release

5-9-12dp: Minor edits for clarity

6-10-13dp: More clarity edits

11-4-2013dp: Typo correction... 13,800Wh was incorrectly 13,8000Wh